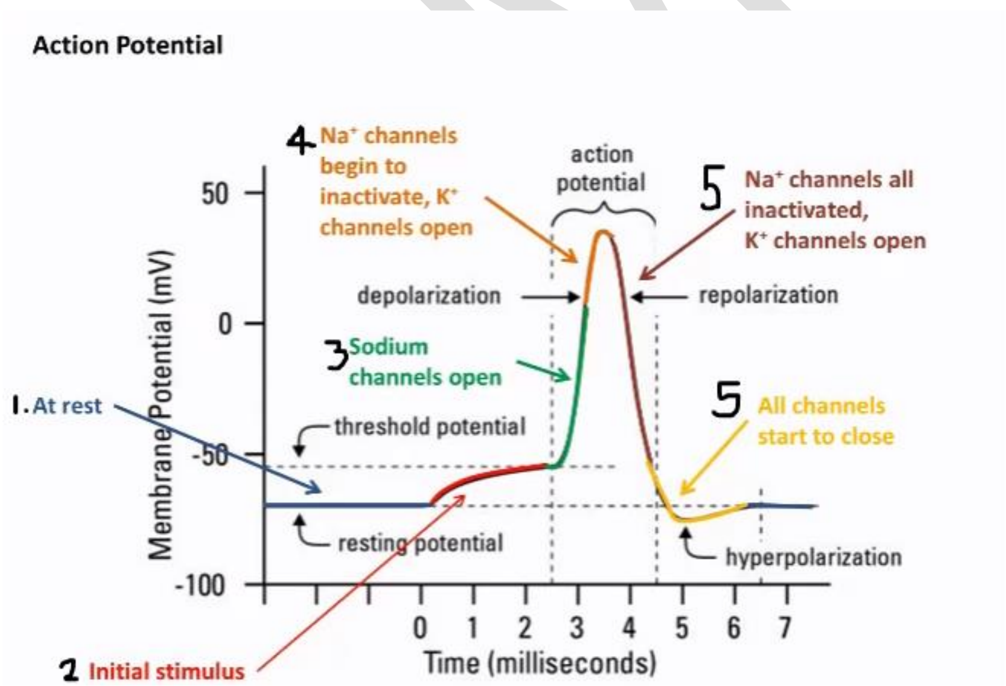
Action Potential

When an electrical current is applied to a cell, it will respond by producing an action potential. This is achieved through an increase in membrane potential caused by the flow of sodium [Na^+] ions into the cell, then returning the membrane to resting potential through the flow of potassium [K^+] ions out of the cell (aided by diffusion of chlorine [Cl^-] ions into the cell).

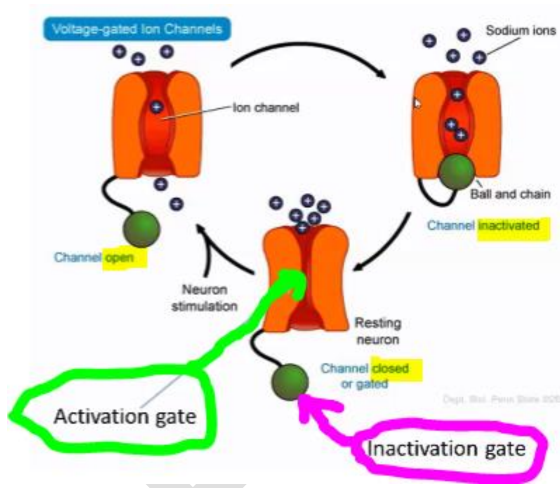
Process

Action potential generally follows a pattern.

1. A cell's resting potential is at -70mV
   - Negative due to leak of potassium ions out of the cell
2. When a stimulus is applied, the membrane potential is increased. If a threshold membrane potential is reached, the sodium channels will open
3. Once the sodium voltage gated channels have opened, sodium will diffuse into the cell, raising the membrane potential to ~40mV.
   - When measuring action potential, this creates a negative current
4. After a period of time, the sodium channels will inactivate, causing the flow of sodium to stop
5. Potassium voltage gated channels will then open, causing potassium to diffuse out of the cell, pulling the membrane potential back to -70mV. This is assisted by chlorine channels opening, resulting in chlorine diffusing into the cell.
   - When measuring action potential, this creates a positive current
   - The membrane potential may drop slightly below resting potential (hyperpolarisation). At this point all potassium channels close.pa



Control of action potential by Voltage Gated Sodium Channels



- The sodium channel can exist in 3 states
  - Closed, open and inactivated
- There are two gates which control the state of the voltage gated channel
  - Activation/voltage gated- dependent on level of neuron stimulation
    - Closed → open
    - Inactivated → closed (5ms refractory period)
  - Inactivation gate- dependent on cell voltage
    - Open → inactivated
- Fast activation

Control of action potential by Voltage Gated Potassium Channels

- Only exist in 2 states
  - Open and closed
- Only have one gate
  - Voltage gate- dependent on cell polarisation
- Take longer to activate than the sodium channels

Proof that action potential is mainly obtained by movement of sodium and potassium

When sodium and potassium are removed from the cell's medium their related portion of the current is lost

- E.g. f there is no sodium in the solution, no sodium can enter the cell and the membrane potential will not rise

Proof that Na+, K+ and Cl- carry charge across the membrane through ion channels

If a specific channel blocker is added to the medium, that section of the current change is lost

- E.g. If a sodium channel blocker is added to the solution, the membrane potential will not rise.
- E.g. If a potassium channel blocker is added to the solution, the membrane potential will not return to resting potential

Action Potential Propagation (movement of signal from one cell to another)

How action potentials propagate along cells

A signal will depolarise a cell past threshold, causing an action potential. This then changes the extracellular environment, stimulating the next cell above threshold causing an action potential, etc.

How Can a Cell Undergo Multiple Action Potentials in its Life

Sodium potassium pumps in the cell membrane then return sodium and potassium to their original places (inside/outside the cell) start that the cell can undergo another action potential the next time it is stimulated

Action Potential Propagation Only Happens in One Direction

From cell A → B → C → D (not from A → B → C and back to A, not from A → B → A again)

Sodium Channel Inactivation

- After the sodium channels deactivate during the action potential, they cannot be opened for a certain amount of time, and therefore cannot react to the stimulus they sent to depolarise the next cell.
- After a certain amount of time, the deactivated channel will close and will then be able to open in response to the next stimulus

Hyperpolarisation

- During the refractory period, the membrane potential is lower than it is at rest. At this time it is harder to increase the membrane potential to the threshold needed for action potential (-35mV)